Implementing Technical Writing into the Undergraduate Steel Design Course

Ernie Heymsfield[1]

Abstract - Undergraduate structural design courses are typically limited to students calculating strength requirements and structural member sizes. However, during the limited semester course time, a student normally is unable to gain a sense of the "grand picture" of a building's structural response or the interaction of the various structural members discussed in the undergraduate steel design class. Additionally, although writing skills are crucial in a job setting, a student normally is not challenged to improve their writing skills in a structural design course. Conversely, if writing is incorporated into the course by examining course specific case studies, the student gains a better understanding of the course material while improving his/her writing skills. This paper presents how technical writing can be incorporating into an undergraduate steel design course and stems from earlier work performed by Dr. John DeWolf at the University of Connecticut.

Keywords: steel design, technical writing, back-of-the-envelope calculations, steel education

INTRODUCTION

Engineering design courses typically neglect technical writing as an effective means to improve student comprehension. Typically material is presented by topical lecture and homework assigned which is solved numerically for reinforcement of classroom concepts. Alternatively, a method is proposed in this paper to enhance student learning in a steel design course by including technical writing homework assignments. The assignments are short reviews of case studies with the objective of having the student gain an overall understanding of the steel building / bridge structural behavior. The approach results in improved student understanding while promoting student interest.

During the Fall 2006 semester, the author was invited by the American Institute of Steel Construction (AISC) to review work being performed by Dr. John DeWolf of the University of Connecticut. Dr. DeWolf's work involved incorporating technical writing into the undergraduate steel design course [DeWolf, 6]. Dr. DeWolf has used writing in his classes over the last eighteen years and is currently using this approach in his Advanced Steel Design Course, a second course in steel design. Prior to reviewing Dr. DeWolf's work, I had exclusively assigned homework requiring calculations to determine the adequacy of a structural member or a required member size. However, after reviewing DeWolf's work, I applied his proposed approach into my Principles of Steel Design Course, a first course in steel design, and found that it was easy to implement and the results promising. Although this article concentrates on implementing technical writing into a steel design course, the procedure can be easily incorporated into other structural type courses such as concrete design or timber design.

BACKGROUND

A typical undergraduate steel design course involves the analysis and design of steel members included in a building structure. The syllabus for the classic undergraduate steel course includes tension members, compression members, beams, beam-columns, and simple connections. The course is taught by reviewing requirements in the AISC steel manual specification [AISC, 1] and then presenting design examples in the classroom for each structural member type. Student comprehension is measured by students determining member adequacy for analysis type problems or required member size in design type problems. However, at this academic level, students are rarely challenged to understand overall building structure behavior or to appreciate structural member interaction. This deficiency can

[1] University of Arkansas, Department of Civil Engineering, 4160 Bell Engineering Center, Fayetteville, AR 72701; ernie@uark.edu

easily be remedied by implementing technical writing into the steel course. This technique motivates the student to take a step back and critically analyze the entire structure rather than only a specific structural component.

The civil engineering students at the University of Arkansas are required to register for two three-credit undergraduate writing courses, Composition I and Composition II. These courses are normally taken during a student's freshman year. After this writing experience, students are not required to take additional writing courses. Therefore, after completing general education core courses, writing is limited and may not be required until a student's senior level project courses. However, a student's success as an engineer often is dependent on their capability to communicate through writing. When a student is employed as an engineer after graduating, a significant portion of their work is related to summarizing or analyzing engineering problems through writing. Although a senior capstone course normally includes writing, exposure to writing at earlier levels is essential for a student to graduate with strong writing competencies. In addition to the benefits of improved writing skills, writing improves a student's course material understanding by requiring a student to critically think through a problem [Bean, 2]. Consequently, the clarity of a student's writing is indicative of their subject understanding.

In a survey of seventeen UA Department of Civil Engineering faculty members, most require students to write, typically lab reports or a project paper. However, courses in environmental engineering and professional ethics are somewhat different. Regular homework in environmental engineering includes calculation work, but also requires a student to write on a news item related to environmental engineering. Homework in the professional issues class is primarily writing. Of structural engineering courses, classes in Structural Loadings and Concrete I require students to write. The structural loadings class requires a report including design loads for a multi-story building. In the Concrete I class, students are required to write a five page report assigned towards the end of the semester. Conversely, the proposed approach in this paper assigns writing assignments throughout the semester investigating a specific issue to complement a topic currently being discussed in the classroom. In addition to writing, students are required to perform back-of-the envelope calculations to confirm either in-depth structural calculations or use in a preliminary study.

IMPLEMENTATION

Although I have implemented technical writing in my undergraduate "Principles of Steel Design" course, the procedure can be easily implemented into other structural engineering courses. The process involves two major components, a writing section and a "back-of-the envelope" calculation section. Although technical writing is emphasized in this article, the student's awareness of the need to be able to do a quick and approximate calculation is equally important. Students are assigned to read an article describing a steel structure and respond to questions about the structure's behavior. The assigned case history article will describe the design and construction of a structure along with intrinsic features of the building. Assignments are prepared to complement course material. Therefore, articles that highlight a specific structural member type are assigned in conjunction with the course material being taught on the specific structural member type. The article should be appropriate to the academic level of the course and therefore should not be overly technically complicated. Appropriated articles can be found in AISC's Modern Steel, ASCE's Civil Engineering Magazine, Engineering News Records, or published case studies. In the 1970's, Bethlehem Steel published a series of case studies which are well suited for this type of assignment [Bethlehem Steel, 3 & 4]. Another resource is the AISC web page where case studies can be downloaded. An article by DeWolf includes examples of case studies used in his classes [DeWolf, 5]. In my class, I assigned the building case history study of The Boston Company Building, published by Bethlehem Steel [Bethlehem Steel, 3].

WRITING SECTION

The homework assignments discussed in this paper include two equally weighted sections, a writing section and a calculation section. The two sections are linked together. The objective of the writing section is to have the student study a specific structural behavior in a case study and conclude how the structural behavior can be approximated to complete the second part of the assignment, namely the back-of-the envelope calculation. The writing section requires the student to read a case study article and concisely describe a particular characteristic of the building designated in the assignment. Assignments are formatted to inspire critical thinking rather than simply having the student summarize the article.

A student's response is limited to a page, approximately 250 words. Students are advised of the reader audience to differentiate whether their writing should address an engineering population or someone unfamiliar with structural behavior. For example, the student may be asked to describe the load path of gravity loads and wind loads transferred through the structure to the structure base. Defining whom the reader is, dictates how the paper should be written. Students are encouraged to use free body diagrams in conjunction with their writing. Although writing mechanics are important, grading emphasis is placed on their effectiveness to convey concepts to the reader. One approach to improve the quality of student writing is to incorporate review and re-review stages in which the student has the opportunity to respond to instructor comments and improve writing format and grammar. Conversely, an alternative to an instructor review is for classroom students to perform the initial review. Either way, using review – re-review stages enhances student learning.

BACK-OF-THE-ENVELOPE CALCULATION

A back-of-the-envelope calculation refers to a solution's brevity. Students apply their understanding of the structural behavior derived in the technical writing section of the assignment to perform specific calculations approximately. Consequently, the back-of-the-envelope calculation challenges the student to demonstrate their understanding of the article. Back-of-the-envelope calculations can be used to quantify a particular building's structural behavior or require the student to determine an approximate minimum member size. Consequently, the goal of this section is to determine the student's material comprehension and to prove to the student how they can validate a load or design a specific structural member approximately. For this section, the instructor may need to supply additional information such as loads, dimensions, or assumptions that may not be included in the article body.

INSTRUCTOR GRADING

A well prepared assignment by the instructor will minimize instructor grading time. An assignment needs to clearly state the question to be answered, designate answer length, and how it will be graded. In addition, stating the assignment objective and instructor expectations will produce good finished writing assignments by the students. Grading is based on answer thoroughness, clarity, and organization. A grading scale of 10 can be used where 5 points are assigned to the writing section and 5 points to the back-of-the-envelope section. For the written section, grading is based on clarity, format, and grammar. A possible grading approach for writing includes a 5 for a well written paper, a 4 for a paper that skips a major point or requires writing improvement. Conversely, a 2 indicates a response that is inadequate in breadth or length. Grading by the instructor should be done in such a way as to improve student comprehension and improve student writing. Therefore, instructor comments are encouraged over simple editing.

The back-of-the-envelope section is easier to grade since it is a numerical solution. Therefore, this section is graded based on approach and accuracy. As in the writing section, this section is graded out of 5. A 5 represents an answer with a correct solution approach and an answer within 20% of the exact solution. Lower grades reflect missing key components or calculation errors. A possible grading approach is summarized in Table 1.

IMPLEMENTATION

In Fall 05 and Fall 06, students of my undergraduate Principles of Steel Design Course class were required to read and evaluate the "Boston Company Building" using the Bethlehem Case Study [Bethlehem Steel, 3]. In this assignment, students were asked to describe the load path of the applied gravity loads to the base of the structure and how the structure frame resists wind loading. In the back-of-the envelope section, students were asked to determine approximately the force in a main diagonal frame member. The questions, format requirements, and grading procedure were clearly stated on a page distributed to each of the students. The assignments were made in November towards the end of the semester as extra credit. Although it was assigned as extra credit, student response was strong. In my 2005 class, the average grade for 14 students was 7.2 while for my 2006 class, the average grade was 7.0 for nine students. Although DeWolf suggests using a review – re-review procedure, which requires students to resubmit their work after responding to instructor comments, I only required a single submittal. In hindsight, it would be better to assign this homework assignment earlier in the semester and have the students resubmit after responding to instructor comments.

Table 1. Instructor Grading Rubric

WRITING SECTION Grade basis: clarity, format, and grammar	**GRADE**	**DESCRIPTION**
	5	Well written and clear. Covers major points.
	4	Skips a major point or needs writing improvement
	3	Skips a major point and needs writing improvement
	3	Skips two major points
	2	Inadequate in breadth or length
BACK-of-the-ENVELOPE SECTION Grade basis: approach and accuracy		
	5	Correct solution approach; answer within 20% of the exact solution
	4	Error in assumption; solution within 30% of the exact solution.
	3	Assumption includes two errors; solution within 40% of the exact solution.
	2	Assumptions include significant errors.

CONCLUSIONS

Incorporating technical writing into an undergraduate steel design course reinforces a student's writing skills, improves material comprehension, and stimulates student interest for the course material. Writing requires thinking and therefore students learn better when they are required to write about a topic. Technical writing assignments motivate students to consider the full problem rather than simply compartmentalizing subject material presented in the classroom. The assignments presented in this paper are two-fold in that they show the student that writing is important and secondly, how approximate calculations can validate solutions derived using more sophisticated methods. In addition, writing and back-of-the envelope assignments stimulate classroom discussion. Although important, technical writing isn't seen to replace the numerical solution requirements needed in a steel design course, but rather to provide a method to complement and enhance a student's experience in the undergraduate steel design course.

REFERENCES

[1] AISC, Steel Construction Manual, Thirteenth Edition, AISC, 2005

[2] Bean, Engaging Ideas - The Professor's Guide to Integrating Writing, Critical Thinking, and Active Learning in the Classroom, San Francisco, CA, Jossey-Bass Publishers.

[3] Bethlehem Steel. Bethlehem Steel Building Case History Number 1: The Boston Company Building, Boston, Massachusetts, Bethlehem, PA, 1970

[4]Bethlehem Steel, Bethlehem Steel Building Case History Number 18: Churchill Academic Tower, Canisius College, Buffalo, New York, Bethlehem, PA, 1972

[5] DeWolf, J.T., Incorporation of Writing into a Steel Design Course, Journal of Professional Issues in Engineering Education and Practice, April 2002, pp 71-74

[6] DeWolf, J.T., Incorporation of Writing Assignments into Steel Design Courses, Report to American Institute of Steel Construction, University of Connecticut, 2006